Tide and storm surge models and operational modelling

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LONG-TERM GOALS

Develop modelling systems for pre-operational use in coastal seas which are easily relocatable, both geographically and across computer platforms.

OBJECTIVES

1) Participate in PCTides OPTEST evaluation on the NW European Shelf
2) Explore link-ups between POL pre-operational modelling and NRL operational modelling

APPROACH

1) PCTides OPTEST evaluation.

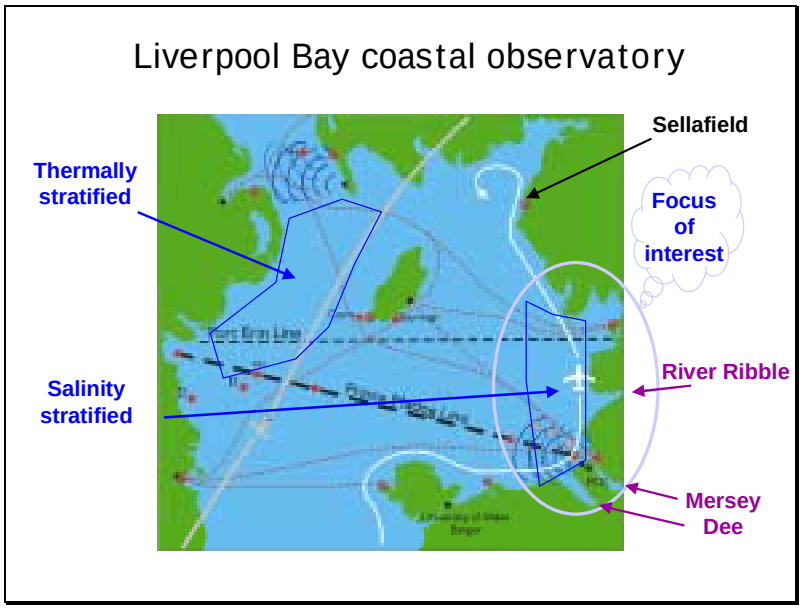
The NRL (Dr Ruth Preller) have recently developed PCTides, a relocatable tide/surge model for use both as an operational system and for rapid assessment application. The model links into the US Navy global atmospheric model (COAMPS) for its surface forcing thus providing a global capability. This system is being installed at numerous US and world-wide naval agencies. The system is currently being validated (OPTEST), and, to ensure wide acceptance, this validation should include as many applications as possible. The North West European continental shelf is an ideal location to carry out a validation. The region has both complex and simple bathymetry / coastal topography and a high density of tide gauges operating in real time against which to assess a models' performance. In addition there are existing operational tide and storm surge models, tuned specifically to the region, which can be used to assess PCTides performance. I was invited to contribute to OPTEST by evaluating PCTides against UK tide gauges and against the UK operational storm surge model.

The evaluation centred on the period 24 April – 27 May, coinciding with my stay at NRL SSC. The evaluation considered only the 2D version of PCTides and the 2D UK tide/surge model, plus observations. The UK model covers the region 48-63N, 12W-13E with a resolution of 1/9 degree latitude by 1/6 degree longitude (approximately 12km) and is driven by tides around the open boundary and hourly surface pressure and winds from the UK Met Office (UKMO) meso-scale (12km) NWP system. The

tide/surge model runs 4 times a day at the UKMO producing a 12-hour hindcast and a 48-hour forecast of water levels (and depth-averaged currents) around the UK coast and along the European continental coast. The model runs without data assimilation. Hourly values of modelled total water level and tidal water level were retrieved from the UKMO by a POL colleague (Jane Williams). Twelve UK open coastal sites (i.e. those not significantly affected by local coastal geometry) and 3 restricted coastal sites (i.e. those in estuaries or affected by other coastal geometry) were chosen for the evaluation. Fifteen minute values of observed water level and harmonically predicted water level were processed and provided by another POL colleague (Libby Macleod). These datasets were obtained in near-real time and made available to me at NRL SSC (and subsequently back at POL). Ruth Preller established 2 levels of PCTide model for this evaluation: a shelf-wide model of approximately 9 km resolution, and higher resolution (3-4km) models centred on the restricted coastal sites. The rationale behind this was that because PCTides is universally relocatable (i.e. it contains global datasets of finite resolution) it would not be expected to perform as well at shelf-scale resolution as the UK model which (although coarser resolution) had been 'tuned' to the shelf response; the higher resolution models (taking boundary data from the PCTides shelf model) should provide a better approximation. PCTides contains the IHO tidal water level database, allowing the model the capability to assimilate into its simulations predicted tidal water levels at IHO sites (coastal and offshore) within the model domain. The NW European shelf is a particularly rich area for IHO data and so a part of the evaluation was how well PCTides performed without assimilation and with assimilation in a data-rich region. In establishing these models a number of bugs in PCTides were discovered and subsequently corrected. Evaluation of these different modelled and observed datasets is still in progress, and a report will be produced when the evaluation is complete.

2) Discussions on other operational / modelling aspects

The new POL Science Plan for 2001-2006 (see www.pol.ac.uk/home/research for details) includes research on coastal processes (including turbulence and sediment transport) which relate to the role of physical forcing in biogeochemical processes. Much of this research is to be set in the framework of a pre-operational 'coastal observatory' focussed on the Irish Sea and Liverpool Bay in particular (see figure below).



It was therefore of interest to me to explore avenues of parallel and complimentary research at NRL which may provide opportunities for future collaboration.

a) Rick Allard (at NRL SSC) is involved with the Distributed Integrated Ocean Prediction System (DIOPS) which provides a global capability for surf forecasts. This system integrates a global wave model (WAM) and regional wave models (STWAVE, SWAN, REFDIF) with PCTides and met forcing to provide water levels for a surfzone prediction model (SURF). This system was of particular interest to me for i) the POL coastal observatory, which plans to run wave models (WAM and SWAN) coupled to a 3-dimensional hydrodynamic model, and ii) the User Interface which allows easy navigation through the different options available.
b) Unstructured grids (e.g. finite elements) have been of interest to POL for some time for their ability to resolve the important horizontal length scales from ocean to estuary in one model. Last year I had discussions with Cheryl Ann Blain about her experiences with QUODDY and ADCIRC, particularly in the Arabian (Persian) Gulf. These discussions were continued, centring on the mass conserving problems of finite element models, with the recent work by Baptista, using a finite volume modification of ADCIRC (L-CIRC) flagged as a potential advance in this area. Also of interest, arising from discusion of the Baptista work, was his web site established for the Columbia River nowcast/forecast system CORIE (www.ccalmr.ogi.edu/CORIE) which has many of the features I want to include in the POL Coastal Observatory website. Cheryl also pointed me to the NAVO web site for the Gulf of Mexico (www.navo.navy.mil/NGLI) as another example of a near-real time ocean observing system.
c) NRL has a global version of its NCOM model running operationally. Discussions with John Harding considered POL access to NCOM products for boundary and initial conditions for POL models. A possible collaboration validating NCOM on the NW European shelf was also discussed. Potential for collaborative work on data assimilation in coastal models was flagged, in particular tying in recent work by Keith Thompson at Dalhousie University. It was felt that this might be pursued through ONR funding.
d) POL (in association with Plymouth Marine Laboratory and Southampton Oceanography Centre) has developed a 3-dimensional coupled hydrodynamic / ecological model for use in oceans and shelf seas which runs efficiently on parallel computers (the Proudman Oceanographic Laboratory Coastal Ocean Modelling System (POLCOMS, see www.pol.ac.uk/home/research/polcoms and Allen *et al* (2001), Ashworth *et al* (2001), Holt and James (2001)). A recent development of this for the Irish Sea , at the eddy-resolving (1.5km) scale, has the capability for 'drop in' modules, allowing the functioning of different ecological models to be examined within the same physical environment. The model presently has 2 ecological models embedded, the European Seas Regional Ecosystem Model (ERSEM) and the Fasham-Anderson model. This system was of interest to John Kindle who, through a NOPP programme, is developing a similar but simpler system involving (N/Si) and diatoms/flagellates and exploring the role of Fe on production in the eastern Pacific. This is still at the 1-dimensional stage of development. We agreed to keep each other informed of developments.
e) The Eastern Irish Sea, the focus for the POL Coastal Observatory programme (see figure), is an area with strong tides and occasional large waves which combine to

give a high suspended sediment load. By contrast in the western Irish Sea (<100km form the Coastal Observatory) has an area of weak tides and low suspended sediment load. In both areas biogeochemical processes are strongly sediment related. A challenge for the 3-dimensional modelling will be to simulate the observed suspended sediment loading as a requisite for modelling the biogeochemical fluxes. For this wave-current interaction and accurate sediment erosion/deposition/transport will be important. Tim Keen has developed a sediment / optics model which we discussed at length with a view to testing within the Coastal Observatory. We are both enthusiastic about this and POL has recently submitted a proposal to the UK NERC in which Tim is a named collaborator. We feel this is an area where ONR funding can be used very effectively with benefits to both groups.

TRAVEL COMPLETED

4 May 2001 Arrive NRL SSC
17 May 2001 Depart NRL SSC

RESULTS

(a) Evaluation of PCTides performance on the NW European shelf compared to UK operational tide/surge model; experience with a relocatable model;
(b) ideas for developing the POL Coastal Observatory website;
(c) ideas on options for coupling wave and current models (DIOPS system);
(d) shared knowledge on ecosystem modelling;
(e) potential for joint work on NCOM applications and data assimilation
(f) potential for collaborative work on suspended sediments through implementation of Tim Keens optics/sediment model within the Coastal Observatory modelling framework;
(g) further insight into the potential of finite element models for baroclinic flows.

IMPACT/IMPLICATIONS

(a) Evaluation of PCTides in a geographically complex but data-rich area will further establish the credibility of the portability of the package;
(b) collaboration on sediment transport modelling within the context of a near-real time coastal observatory can result in improved algorithms and be of benefit to the wider community;
(c) increased awareness of developments in operational modelling in both UK and US will benefit both groups;
(d) information gathered on finite element modelling and the development of websites for near-real time and operational systems will accelerate realisation of the POL Coastal Observatory.

TRANSITIONS

Operational modelling systems and near-real time coastal observing systems are becoming major tools in the monitoring and management of the marine environment, particularly in shelf seas. Pooling US and UK experience can lead to improved monitoring systems worldwide.

RELATED PROJECTS

POLCOMS – POL Coastal Ocean Modelling System, a modular 3-dimensional modelling system for ocean / shelf seas (www.pol.ac.uk/home/research/polcoms)

The POL Coastal Observatory (www.pol.ac.uk/home/research)

The Columbia River nowcast/forecast system (www.ccalmr.ogi.edu/CORIE)

PUBLICATIONS

1. Allen J. I., Blackford J. C., Holt J. T., Proctor R., Ashworth M. and Siddorn J. (2001). A highly spatially resolved ecosystem model for the North West European Continental Shelf. *Sarsia*, in press.
2. Ashworth, M., Proctor, R., Holt, J.T., Allen, J.I. & Blackford, J. (2001). Coupled Marine Ecosystem Modelling on High-Performance Computers. Proceedings of ECMWF Conference on High Performance Computing, in press.
3. Holt J. T. and James I. D. (2001) An s-coordinate density evolving model of the north west European continental shelf. Part 1: Model description and density structure. *Journal of Geophysical Research*, in press.